

**EVALUATION OF ASSUMPTIONS
USED TO DEVELOP THE ALABAMA CSEPP
PROTECTIVE ACTION RECOMMENDATION GUIDEBOOK**

Report prepared by the
National Institute for Chemical Studies
Charleston, West Virginia



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and
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SECTION 1: INTRODUCTION

1.1 PURPOSE

The National Institute for Chemical Studies (NICS) was tasked by the U.S. Army, SBCCOM, to conduct an independent evaluation of the assumptions used in generating the data to support the Alabama CSEPP Protective Action Recommendation Guidebook (Wilson, et al. 2000). The Guidebook is a manual reference developed by Innovative Emergency Management, Inc. (IEM) for FEMA's Program Manager for Chemical Stockpile Emergency Preparedness. The purpose of the Guidebook is to assist jurisdictions in the Alabama CSEPP community in making a protective action decision in the event of an accidental release of chemical agent from the Anniston Chemical Activity (ANCA) site.

This report provides the results of the NICS evaluation of the Guidebook assumptions.

1.2 BACKGROUND

The Guidebook is intended for use in an emergency response. In the event of a chemical accident or incident at ANCA, the Guidebook provides step-by-step instruction to emergency personnel for making a quick and effective protective action recommendation (PAR) for persons in the zones surrounding ANCA. This recommendation will be to either shelter in place or evacuate.

All of the recommendations made in the Guidebook are based on IEM's proprietary suite of simulation tools called QEM-World™. This suite of tools includes an evacuation model and a sheltering model and takes into account a multitude of variables. All protective action recommendations made by the Guidebook are based on the assumptions in IEM's Scenario and Critical Evaluation Element Report (SCEER)(Lemcke, et al. 2000).

The assumptions used to generate the Guidebook were developed by the Alabama CSEPP Integrated Process Team. Membership on this team includes the Anniston Chemical Activity, FEMA, the Alabama Emergency Management Agency, and Alabama CSEPP county officials. These assumptions are documented in the SCEER and the Technical Addendum to Alabama CSEPP Protective Action Recommendation Guidebook - Revised (Wilson et al.2001).

Since the publication of the Guidebook, some team members have questioned the validity of certain assumptions that were used as inputs. Other team members have questioned whether the recommended protective actions provide an adequate level of protection to the public.

By memorandum dated April 4, 2001, Raymond Fatz, Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health, directed that the Guidebook not be approved for use until the questions raised by the team were resolved. To resolve these questions, Deputy Assistant Secretary Fatz requested an independent expert review to identify and validate the most risk-sensitive assumptions that were used as inputs to the Guidebook.

The review was to focus on two issues: (1) whether the assumptions are reasonable and appropriate and whether they account for all factors that significantly affect risk; and (2) the extent to which the protective actions recommended by the Guidebook protect the general public and reduce risk. It was further determined that the methodology and technical basis for the modeling used to develop the Guidebook should be considered but did not need to be validated since neither had been challenged and both have been generally accepted by the CSEPP community.

On July 13, 2001 a purchase order was issued by the U.S. Army CSEPP office to the National Institute for Chemical Studies (NICS) to conduct this independent review. The Purchase Order directed NICS to review the supporting information and determine the appropriateness of the assumptions that were employed in the Alabama CSEPP Risk Analysis and the resultant Protective Action Guidebook. Specific tasks to be performed included:

- (1) Review all relevant documentation, visit Alabama emergency managers and meet with personnel from Innovative Emergency Management, Inc. to gather background, identify critical assumptions, and establish the basis for assumptions used in the study.
- (2) Research all relevant published information to identify existing bases for establishing the assumptions employed in the Alabama CSEPP Risk Analysis and Protective Action Guidebook.
- (3) Using the above information, evaluate each of the assumptions and determine their reasonableness and if necessary recommend alternative values for the assumptions.

- (4) Prepare and submit a report evaluating each of the assumptions and conclusions regarding use of the assumptions.
- (5) Present the results of the evaluation and the report in Washington, D.C. on August 30, 2001 to FEMA, Army and local personnel. (This date was subsequently changed to September 10, 2001).

1.3 LIMITATIONS ON THE REVIEW

This review focused on the assumptions used as inputs for the Guidebook. In accordance with the April 4, 2001 memorandum from Deputy Assistant Secretary Fatz, this review does not attempt to validate the methodology and technical basis of the modeling used to develop the Guidebook.

The review was also limited by the abbreviated time available to conduct the review and deliver the final report. This time was further constrained by the fact that the review relied on the delivery of key documents and the performance of a sensitivity analysis of the assumptions by IEM, both of which were initiated at the same time as the NICS review. As a result, the NICS review was based primarily on a review of documents provided by IEM and SBCCOM, and did not include an exhaustive review of the literature. While NICS believes these constraints do not effect the validity of its findings and conclusions, they are noted as part of the report.

1.4 ORGANIZATION OF THIS REPORT

This report is organized in three parts. **Section 2** identifies the methodology used to conduct the review. **Section 3** identifies and evaluates each of the assumptions that were identified. **Section 4** provides the findings and conclusions of the review. The **Appendix** lists the resources reviewed by NICS in conducting the evaluation.

SECTION 2: METHODOLOGY

2.1 Review all relevant documentation, visit Alabama emergency managers and meet with personnel from Innovative Emergency Management, to gather background, identify critical assumptions, and establish the basis for assumptions used in the study.

NICS began the review by meeting with IEM staff at corporate headquarters in Baton Rouge, Louisiana on July 18 to receive a briefing on the Guidebook and the methodology and technical basis for the modeling used in its development. IEM personnel presenting the briefing were Ted Lemcke, Vice President, Core Technologies; Brian Boyle, Division Manager, Test, Exercise and Evaluation; and J. Krause Wilson, Statistician. The briefing focused on: (1) background on the QEM model and its role developing the Guidebook; (2) purpose and use of the Guidebook; (3) critical Guidebook assumptions (modeling parameters); and (4) sensitivity analysis of the assumptions. Copies of the Guidebook and key support documents were provided by IEM to NICS at this meeting.

NICS next traveled to the Anniston area August 15 - 17 to meet with Alabama CSEPP state and local emergency managers. These meetings were designed to enable local personnel to describe their involvement in development of the Guidebook and its assumptions, and to identify any issues or concerns with use of the Guidebook related to the assumptions. NICS staff met with the following individuals during this time:

Alabama Emergency Management Agency (AEMA)

John Duncan	Preparedness Division Manager
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Anniston Chemical Activity (ANCA)

Jack Phelps	Civilian Executive Assistant
Joe Hafley	EOC Team Leader
Pat Bell	EOC Operations Technician
Adam Hill	EOC Operations Technician
Don Broderson	CSEPP Coordinator

Clay County EMA

Theresa Daugherty	Director
Anne Poole	Planner

Cleburne County EMA

Burt Collison	Operations Officer
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Etowah County EMA

Marie Bankson	Director
Dave Waits	Operations Officer

St. Clair County EMA

Ellen Haynes	Deputy Director
Bryan Schaefer	CSEPP Planner

Talladega County EMA

Buddy Holcomb	Director
Dee Dee Hill	Deputy Director

Due to scheduling conflicts, officials from Calhoun County EMA were unavailable to meet during this period. A subsequent conference call to discuss the assumptions with Calhoun County officials was held on August 31. In addition to NICS staff, participants on the call were:

Mike Burney	Director, CCEMA
Delois Champ	CSEPP Planner
Bill Norris	Applied Computer Sciences
Robert Downing	Calhoun County Commissioner
David Springer	Counsel for Calhoun County

Additional documents relating to the Guidebook and its assumptions were obtained from IEM, SBCCOM, and other sources. A list of all the resources reviewed for this study are included in the Appendix.

Based on these meetings and the document review, a list of assumptions used in development of the Guidebook and a description of the bases for the assumptions was developed. This information is provided in Section 3 of this report.

2.2 Research all relevant published information to identify existing bases for the assumptions.

From the meetings and the document review described in Section 2.1, NICS identified key source documents that provided the bases for the Guidebook assumptions. This information was reviewed to clarify the rationale behind the assumptions. Additional documents relevant to the assumptions were identified and reviewed by NICS. These resources are included in the Appendix.

2.3 Using the above information, evaluate each of the assumptions and determine their reasonableness and if necessary recommend alternative values for the assumptions.

For each assumption, NICS used the information described above to determine the following:

- (1) Is the assumption reasonable and appropriate, given the current state of knowledge about protective actions during chemical emergencies and the current state of preparedness in the Anniston CSEPP communities?
- (2) Does the assumption take into account all relevant risk factors, or are there other factors that should be considered?
- (3) Do the protective actions recommended in the Guidebook, as they relate to this assumption, protect the general public and reduce risk?
- (4) Are there any specific changes to the assumption that should be recommended? If so, identify the changes and any replacement values for the assumption.

The results of this evaluation are provided in Section 3 of the report.

2.4 Prepare and submit a report evaluating each of the assumptions and conclusions regarding use of the assumptions.

This report has been prepared by NICS to present the results of the evaluation. Included in the report are findings and conclusions regarding the assumptions for consideration by the Army and FEMA. An oral presentation of the evaluation and its findings will be presented to the Army and FEMA on September 10, 2001.

SECTION 3: IDENTIFICATION AND EVALUATION OF ASSUMPTIONS

This section identifies and evaluates the critical assumptions used in generating the data to support the Guidebook.

During the information gathering phase of this project, NICS identified several individual assumptions and groupings of assumptions in various support documents. Based upon representations by IEM, NICS believes that the most critical assumptions used to support the Guidebook are those identified in the Scenario and Critical Evaluation Element Report (SCEER). These same assumptions are listed in the November 10, 1999 correspondence from IEM to AEMA as the final list of assumptions to be applied in the full QEM analysis. These are grouped as follows:

- (1) Baseline data assumptions
- (2) Response modeling assumptions
- (3) Assumptions relating to calculation of zone risk
- (4) Shelter in place assumptions
- (5) Evacuation assumptions
- (6) General assumptions

3.1 Baseline Assumptions:

3.1.1 No analysis of Zone M-1.

Zone M-1 is a military zone that includes the chemical agent storage and disposal area. Protective actions for personnel in Zone M-1 are managed by the military and will not affect community preparedness and response.

3.1.2. Zone M-2 population as modeled in SOW 1 Evacuation Time Estimate (ETE) work.

Zone M-2 is a military zone. Personnel present in Zone M-2 will evacuate only in large-scale accidents. This assumption is appropriate based on military policy for this zone.

3.1.3. Zone M-3 (Ft. McClellan) population as provided by the Joint Powers Authority (JPA).

FY 2000, Day 700, Night 300

FY 2001-2007, Day 1700, Night 500

The population of Zone M-3 for both day and night should be accepted. Population estimates provided by the JPA are the best data available.

3.1.4. All non-military zone populations used in the simulation will be as prepared for the SOW 1 ETE analysis completed in May 1999.

Non-military zone populations were derived from 1990 Bureau of Census TIGER and associated data files. Population projections to 1998 were performed using standard Bureau of Census methodologies. Population estimates based on time of day were based on a time budget analysis of the U.S. population (Juster, et al., 1988). Use of Census data and projections for population estimates is a well-established and standard practice. The time budget study used for estimating day versus night population patterns is also considered a standard and has been cited by numerous researchers. This assumption is appropriate.

3.1.5. The simulation will use the most recent five contiguous years of weather data from the Handar tower DA0012 at ANCA.

The weather data used from the Handar tower DA0012 at ANCA meets the USEPA standards for quality control and missing data records (EPA, 1999). Data at the tower were collected every 15 minutes and included such weather information as wind speed and direction. Five years of data allow for a large database of potential weather conditions and combinations. For modeling purposes, all unique weather conditions recorded at this tower were used. Although a single tower cannot characterize all weather conditions that may occur over a large area at a single point in time, for purposes of modeling the variety of conditions that may affect

plume dispersion, data gathered from Handar tower DA0012 are sufficient to capture weather conditions that might occur during a chemical agent incident at ANCA.

- 3.1.6. Air change rate distributions will be assigned to residential and non-residential (industrial and commercial) populations based on site land-use categories developed for the Land Use Database tasked in Statement of Work for Quantitative Emergency Management (QEM) Analysis of Protective Action Options at the Anniston CSEPP Site (March 9, 1998).

Predicting air infiltration rates of particular residential, commercial and industrial buildings is difficult without extensive field work. Measuring air infiltration rates directly is usually accomplished by blower door or by tracer gas methods. Blower door studies place the house under pressure, and as such, air leakage rates are higher than under normal conditions. Typically, readings acquired through blower door studies are divided by some factor to estimate what air leakage would be under normal pressures. Tracer gas techniques involve introducing a known quantity of a tracer gas into a building and measuring the rate at which the gas concentration decreases. The rate can be converted directly to an air exchange rate (see Blewett, et al. 1996).

Although air exchange rates for groups of buildings could be measured by these techniques, it would be impractical and prohibitively expensive. Air exchange rates for buildings are not constant. A number of factors including temperature, wind speed and direction, among others affect how fast air moves into and out of a building.

IEM used land use categories of residential, commercial and industrial for developing the air exchange rate distributions used in modeling for the guidebook. Data from the East Alabama Planning Commission were used to characterize zones and smaller subdivisions of zones. Residential air exchange rate distributions were taken from a study conducted by Murray and Burmaster (1995). This study used data compiled by Brookhaven National Laboratory using the tracer gas technique to estimate probability distributions of air exchange rates for residential structures in different geographical regions of the U.S. While these data do not fully represent all areas of the country, they were judged by the authors to be by far the best available.

The Murray and Burmaster distributional approach recognizes that air exchange rates are not constant for structures. That is, for a particular structure type in a given region, air exchange rates follow some distribution. Their analysis indicated that the distribution was best characterized as log normal. IEM used this log normal distribution for the residential and undeveloped land categories because of the structure types found in these land use categories. For commercial and industrial land use categories, IEM applied the Murray and Burmaster approach to data compiled from the Air Infiltration and Ventilation Center (AIVC) Numerical Database (a product of the Center, see <http://www.aivc.org>). These data were collected by the blower door method.

It should be noted that the air exchange rates from both the Brookhaven National Laboratory data and the AIVC database are based on normal conditions in residences, that is, air conditioning/ heating systems on and interior doors open. The air exchange rates for these houses would be higher than for houses taking normal or expedient sheltering actions. As such, the air exchange distributions used in modeling for the guidebook contain conservative estimates. The log normal distributions yield a curve that shows that 90% of the houses should have an air exchange rate of 1.94 or lower.

The methods and data used by IEM to develop the air exchange rates and land use categories for modeling are based on the technically sound data and methodologies. The air exchange rates are conservative and should provide a reasonable basis for determining the suitability of a zone for sheltering in place.

3.2 Response Modeling Assumptions:

3.2.1 Sirens will be assumed in the protective action zone (PAZ) in areas of high population density.

For guidebook modeling, it was assumed that sirens would be installed in areas of high population density in the protective action zone (PAZ). Interviews with John Duncan from the Alabama Emergency Management Agency (AEMA) and emergency managers from PAZ counties acknowledged that all sirens were not yet in place. Mr. Duncan indicated that AEMA accepted this assumption based on the future installation of sirens. The paper guidebook would be published only once and AEMA felt that it would be inappropriate to base it on conditions that would be out of date in a relatively short period of time. Most counties believed that the remainder of the approved sirens would be installed no later than April 2002.

NICS believes that the assumption is reasonable for a paper-based guidebook. However, if some of the needed sirens are not installed, this assumption should be reevaluated. Sirens are important in warning diffusion which is a critical component in public response.

3.2.2. Cycle times provided by Calhoun County Emergency Management Agency (CCEMA) for siren activation and confirmed by Whelan Engineering will be incorporated in the simulation.

Vendor information is appropriate for this assumption.

3.2.2.1 Siren activation cycle times will assume availability of encoder software that allows rapid activation of sirens and simultaneous activation of zones by cluster.

Interviews with CCEMA officials indicated that Calhoun County sirens will be activated sequentially. CCEMA officials felt that it would be impractical to cluster zones adequately to account for all possibilities of plume movement. For this reason, this assumption is incorrect. The time needed to warn the public in Calhoun County is greater than implied by simultaneous activation of zones. Should simultaneous activation prove impossible, time needed for sequential activation should be incorporated into the model.

3.2.3. Tone alert radio (TAR) activation cycle times will be as provided by the TAR contractor.

Vendor information is appropriate for this assumption.

3.2.4. General Population TAR activation time will vary by scenario, depending on how many different messages are required to be issued. When multiple messages are assumed, sequential activation by message will be modeled. TARs in special facilities will be assumed to activate simultaneously.

According to county emergency management officials across the PAZ, tone alert radios have yet to be installed in all of the county's structures. There is some concern that TARs will not be installed by April due to manufacturing delays and inability to effectively distribute TARs to all residences in zones where they are needed. County emergency managers agreed that the activation assumptions accurately reflected their capabilities. Again, TARs are important in warning

diffusion, and if their installation is not completed, warning diffusion times associated with the alert and notification system should be modified to reflect the lack of TARs.

3.2.5. Response will be modeled based on a “perceived hazard,” while dosage to population will be evaluated based on the “actual hazard.”

- IEM will use MCEs currently used by ANCA to generate the “perceived hazards.”
- QRA accident source terms will be used to generate “actual hazards.”

In the very early stages of an incident, it is rarely possible to completely characterize every factor that may affect plume concentration and dispersion. However, it is extremely important to begin emergency response as soon as possible. In the first minutes of an incident, the Depot would transmit a Protective Action Recommendation (PAR) based on the maximum credible event (MCE) for the day’s operation. Response would be initially based on this MCE (interview with K. Wilson, IEM). Generally, the MCE would yield a more severe accident than actually occurs. Response would be based on this MCE and would likely result in protective actions for people not actually at risk.

The actual event would be some accident associated with the daily operations that yielded the MCE, but most likely would be less severe. As more information becomes available in a real accident, off-post areas that are at risk can be more closely defined. All of the QRA (quantitative risk assessment) accidents (see Science Applications International Corporation 1997) associated with an MCE were modeled to evaluate the dosages that might be received by the public.

The generation of PARs based on MCEs produces a conservative approach to protecting the public. In an actual event, more people would be advised to take protective actions than were actually at risk. This is an appropriate policy for protecting the public and is a common policy among emergency management agencies across the country.

3.2.6. Mobilization and Warning Diffusion distributions will be as defined for the SOW 1 ETE work, with the exception of PAZ areas now assumed to have sirens. For these exceptions, zone distributions will be modified to account for the change in alert and notification mechanism.

Warning diffusion and mobilization distributions were taken from the classic work on this issue (Rogers, et al. 1990). The warning diffusion distributions presented in this work are for sirens, tone alert radios, media, telephone, siren and TAR together, and siren and telephone together. The distributions do not reflect any public education campaigns to decrease the time necessary to mobilize. Absent any direct data for warning diffusion and mobilization in CSEPP communities, the distributions in the Rogers et al. report are an appropriate substitute. The assumption that sirens are present is discussed in Section 3.2.1.

3.3 Assumptions Associated with Calculations of Zone Risk:

3.3.1. The Public Protection Criterion IEM proposed in Public Protection Criterion: a Publication Review for Alabama CSEPP, June 28, 1999, IEM/TEC99-041 will be used as the decision criterion for shelter in place recommendations.

IEM proposed a decision criterion for shelter in place recommendations that is quantitatively expressed as a risk of fatality of 4×10^{-7} /yr or the frequency of fatality would not be expected to exceed one in 2.5 million per year. This criterion is based on 0.1 of 1% of the risk to all U.S. citizens of death from all kinds of accidents including automobile accidents, fires, falls, and drowning among others. In all areas of the United States, even those areas not close to obvious industrial accident sources, people share some risk of accidental death. That rate is estimated to be 4×10^{-4} /yr, or 1 in 2,500 per year (Krantz 1992). This means that the risk of accidental death from all other accidents in the United States would be 1,000 times greater than the risk of death from an accident from ANCA and demilitarization activities if the public protection criterion is met. The same risk criterion is used by the Nuclear Regulatory Commission (NRC, 1986).

The level of “acceptable risk” is, at its core, a public policy issue. This public protection criterion for risk modeling associated with the Guidebook was adopted by FEMA and the Department of the Army on March 31, 2000. This level of risk is reasonable and consistent with the policies in CSEPP Policy Paper No. 1.

3.3.2. Reduction of risk over time due to completion of demilitarization campaigns was not incorporated in this analysis. Thus, risk estimates presented in this work will decrease as each campaign progresses.

Although risk to the public should lessen as the chemical agents are destroyed, it is conservative to ignore that risk reduction for purposes of modeling. As the most dangerous chemical weapons are destroyed (M55 rockets), overall risk from the depot and incinerator will drop dramatically. In keeping with the overall conservative nature of modeling for the guidebook, it is reasonable to disregard the risk reduction that will occur as a result of demilitarization.

3.4 Shelter in Place Assumptions:

3.4.1 The analysis will be conducted for normal shelter in place and expedient shelter in place options.

Normal sheltering in place can be accomplished by nearly every citizen, and expedient sheltering by most, with relative ease. Normal sheltering in place requires only that doors and windows be closed and that HVAC systems be shut down. Expedient sheltering adds the addition of a “safe room” concept. For expedient sheltering, a room with few or no windows is sealed with plastic sheeting and duct tape to further reduce infiltration of outside air into the structure. Enhanced sheltering requires that homeowners apply weatherization techniques to their homes. While still not difficult, it does require advance activities and a certain expense. Pressurized shelters can effectively eliminate risk from chemical agents but are extremely expensive to install and maintain. It is appropriately conservative to assume only the easiest sheltering options when assessing risk to the population around ANCA when sheltered in place.

3.4.2. The primary success criterion for zone shelter in place evaluations is that 100% of the zone population does not exceed the No Effects dosage.

According to the Guidebook and the Technical Addendum, it is expected that sheltered populations will not receive greater than the No Effects dosage when emergency response is “On Time.” This is expected to be the case most of the time. This success criterion is appropriately protective and consistent with CSEPP policy. (See CSEPP Policy Paper Number 1)

3.4.3. The secondary success criterion for zone shelter in place evaluations is that 100% of zone population does not exceed the No Deaths dosage.

There is acknowledgment in the Guidebook and its supporting documentation that emergency and public response times may not always be timely. In those cases, the No Deaths dosage was chosen to represent a secondary success criterion. It must be recognized that not all people in sheltered zones would be exposed to concentrations that would lead to the No Deaths dosage. That is the upper limit for this secondary success criterion. If the No Effects dosage has been exceeded, evacuation becomes even more problematic. An early symptom of nerve agent exposure is miosis (pinpoint pupils) which would significantly impair driving ability. Should an accident occur during evacuation, the evacuating public is potentially subject to much greater exposures than would be received in a shelter – perhaps even accumulating dosages higher than the No Deaths dosage. In these cases, it is prudent to shelter in place even if some effects may be expressed from exposure to nerve agent.

While the goal of all emergency managers is to prevent exposure to harmful amounts of chemical agents, it is not always possible to manage an accidental release so that goal is met. It is appropriate to recognize both a primary and secondary success criterion given the realities of emergency management.

3.4.4. Air change distributions will be used, as documented in Public Protection Criterion: a Publication Review for Alabama CSEPP, June 28, 1999, IEM/TEC99-041.

See discussion under Section 3.1.6. The air change distributions seem adequate to describe the adequacy of sheltering in place as a protective action.

3.4.5. People are assumed to vacate their shelters following passage of the plume at the shelter location.

In order to shelter in place effectively, people must not only close up their structures promptly when warned, but also must ventilate/vacate their structures as soon as possible following passage of a toxic plume. Sheltering in place does not prevent exposure to toxic materials in the outside air. Sheltering can minimize exposure and accumulation of dosage by limiting the amount of air that infiltrates from the outside. When the outside air is clear, inside air may contain

contaminated air. If a sheltered individual remains in the building, he or she will continue to be exposed to the contaminant.

If people are to vacate/ventilate a shelter following passage of the plume, there must be a way to determine when the tail of the plume has passed and a way to notify the public to vacate and ventilate their homes. The D2PC model in use by ANCA and the CSEPP Counties calculates tail times for plumes (Lemcke and Myirski 1994). While there are uncertainties associated with all models, models are constructed to provide conservative estimates. The Emergency Alert System is available for providing ventilation instructions and advice to leave the shelter. According to IEM, the model assumes that people leave their shelters one minute after the tail of the plume passes. This is based on an assumption that emergency managers can alert and notify sheltered zones that the tail will pass and that sheltered individuals should vacate/ventilate in 10 minutes or so while the plume is still present (email message from K. Wilson, IEM).

Training and exercising may make this a reasonable assumption. However, it will require that the county EOCs be fully aware and ready to make these EAS announcements and that a strong public education program be implemented to fully inform the public of the need to vacate/ventilate in a timely manner. While the time to vacate/ventilate shelters may be longer than one minute after tail passage, we have found no data to support another value for that time.

3.4.6. The simulation will not assume additional dosage accumulation once people vacate the shelter.

If people vacate/ventilate shelters promptly after the tail of a plume has passed, no additional dosage should be accumulated from inhalation. Concern has been expressed by some county officials about the persistence of HB and VX. Aerosol deposition is possible but unlikely for these agents in the community beyond post boundaries (Argonne National Laboratory 2001). Nonetheless, the possibility should be considered by the ANCA EOC and recommendations made accordingly. The conditions under which deposition might occur are known and in those cases, a terminate shelter message might be crafted to instruct sheltered individuals to maximize the ventilation of their homes, but to stay inside. For purposes of modeling for the guidebook, it seems appropriate to assume no or insignificant additional dosage accumulation after the shelter is vacated.

3.4.7. Thirty-seven pre-determined special facilities will be treated with positive pressure capabilities along with the Jacksonville State Trooper post (for a total of 38 facilities).

Originally, SOW 1 indicated that 38 total facilities would have positive pressure capabilities. At present some smaller number of facilities will eventually be pressurized. According to Russell Salter of FEMA (letter to Mr. Randy Wood, Chairman, Calhoun County Commission, June 12, 2001), positive pressure projects are underway for 5 facilities, bids are being taken for 9 more facilities, 6 facilities are being assessed and 7 facilities have been assessed and determined to need only normal or expedient sheltering for adequate protection. An additional 11 facilities are being studied by the Alabama CSEPP team "to ensure that vulnerable populations were not overlooked in the original Team collective protection selection process". Any collective protection facilities which will now evacuate or apply normal or expedient sheltering will need to be incorporated into the overall model of protective actions and risk assessment.

3.5 Evacuation Assumptions:

3.5.1. Zone M-2 will be modeled as it was in ETE work (evacuations only take place in large-scale accidents).

Zone M-2 is a military zone and will be subject to military policy for emergency response. Should military policy for evacuation change, this assumption should be modified.

3.5.2. The primary success criterion for zone evacuation evaluations is that 100% of evacuating zone population does not exceed the No Effects dosage.

Evacuating residents will be in vehicles which provide only limited protection from airborne contaminants. Vehicles are designed to have good ventilation to prevent the accumulation of carbon monoxide and other exhaust gases. Evacuees should not be exposed to levels of nerve agent that exceeds the No Effects dosage. One of the earliest symptoms of exposure to nerve agent is miosis which causes the pupils of the eye to diminish and decreases visual acuity. Drivers with hindered vision increase the risk in evacuation. Automobile accidents during evacuation could strand motorists in the plume and potentially expose thousands of people to life-threatening levels of agents. Therefore, it is prudent and protective to recommend evacuation when expected dosages will not exceed the No Effects

level.

3.5.3. Dosages will be accumulated for evacuating populations until they exit the Risk Area.

As long as evacuees are in the Risk Area, or that area affected by a plume of agent, dosages at some level may be accumulating. As noted above, vehicles provide only minimal protection from air-borne agents. This assumption is reasonable and protective.

3.5.4. Zone interactions during multi-zone evacuations are assessed in the simulation.

It is appropriate that interactions among evacuees from different zones be assessed. Whether the evacuation is phased or simultaneous, vehicles from various zones will interact while evacuating.

3.5.5. All 10 community conditions will still be evaluated as previously defined in Statement of Work for Quantitative Emergency Management (QEM) Analysis of Protective Action Options at the Anniston CSEPP Site (March 9, 1998).

Population levels and road networks were evaluated at a single point in time. While there may have been some changes since this work was done, it is appropriate when producing a paper-based guidebook that community conditions be evaluated at some recent time so that information could be effectively used in the modeling to support development of the guidebook.

3.5.6. The road network defined for the simulation will be as constructed for the SOW 1 ETE work and as modified based on feedback from site jurisdictions in May and June 1999 (in conjunction with delivery of preliminary ETEs).

The evacuation network was modeled using input from county emergency managers on current and planned evacuation routes. The existing roadways and any soon to be completed roadways are appropriate for use in modeling. Given the length of time necessary to acquire right-of-ways, design and build highways, it is not appropriate to model planned highways.

3.5.7. User equilibrium routing will be assumed on the road network as defined for the site jurisdictions at preliminary ETE meetings in May 1999.

User equilibrium routing takes into account the ability of people to choose their own way to main evacuation routes. However, pure user equilibrium routing models do not factor in the effect of emergency management efforts to encourage the use of prescribed evacuation routes. According to IEM (Wilson 2001), the proprietary model QEM-World™ ensures a preference for prescribed evacuation routes, but also takes into account the likelihood that some evacuees will choose their own routes. User equilibrium routing with adjustments for emergency management activities is a reasonable way to account for individual choice in routing.

3.5.8. Routing for individual zones under primary, alternate or split conditions (as applicable) will be as coordinated through county visits in June 1999, in a meeting with CCEMA in July 1999, and through a number of phone conferences with AEMA in August/September 1999.

Evacuation route selection was coordinated with county and state officials. Emergency managers from the CSEPP counties explained their use of plume direction to determine evacuation route selection. Incorporation of route selection techniques actually in use by local emergency managers is an appropriate input for modeling evacuation feasibility and time estimates.

3.5.9. Zones where evacuation under the above assumptions does not meet the success criteria will be assessed for likely success with advanced traffic management enhancements.

IEM conducted an Advanced Traffic Management study for zones where the population was not protected effectively by sheltering in place. An evacuation feasibility analysis (EFA) was conducted to determine where traffic congestion might preclude a successful evacuation. IEM was able to determine the likelihood of successful evacuation (LSE). This index defines successful as 90 percent of the population able to leave the emergency planning zone prior to accumulating a No Effects dosage. The EFA identified improvements in the traffic network that would increase the LSE, that is, increase the likelihood that the zone would be able to evacuate successfully. IEM identified several zones where advance traffic management would increase the LSE and make evacuation a more viable option.

The recommendations that resulted from the Advance Traffic Management study were not incorporated into modeling for the Guidebook. This is appropriate since the recommendations are just that, and have not been approved or implemented.

3.5.10. Sections of Interstate 20 slated for expansion (22 miles between Estaboga and Golden Springs) will be modeled as four lanes, two in either direction.

NICS is unaware of the construction schedule for Interstate 20. However, if the expansion will be complete in a reasonable period of time (for instance, within a year), it seems appropriate to model its availability in evacuation time estimates. The production of a paper guidebook, by necessity, means that using only current conditions may make the guidebook obsolete in a short period of time. If Interstate 20 expansion will be delayed much past one year, NICS believes that it should not be considered available for evacuation in this guidebook. Its availability can be assessed as the guidebook is automated.

3.6 General Assumptions

3.6.1. Results will be provided in an operational framework consistent with implementation in CSEPP automation and the Automated Reference Number System (ARNS). Implementation or cross-referencing with ARNS will not be done as part of this work.

All counties (with the exception of Calhoun) indicated that the Automated Reference Number System was crucial for their emergency management activities. It is appropriate that the results from this effort be consistent with ARNS and with on-going guidebook automation work.

3.6.2. There may be some zones that cannot shelter in place or evacuate and meet proposed risk or response-based criteria under selected hazards conditions.

3.6.2.1. Under these conditions, critical scenario characteristics will be identified and provided as decision points for protective action determinations for some zones under some conditions.

In the “pink zones”, that is, zones where neither sheltering in place nor evacuation meet risk or response-based criteria, IEM recommended additional emergency

management be applied (Lemcke 2000). This led to the development of additional critical scenario characteristics and assumptions for the 6 pink zones. The assumptions were intended to be more representative, in general, of the conditions currently in place in those zones. Specific assumptions that differ from those used in modeling for the Guidebook include:

- Warning diffusion distributions will be based on the alert and notification type currently available in each zone, with the exception of the TARs in the immediate response zone and sirens, as specified by FEMA. (With automation of the guidebook coming soon, it seems reasonable to use current or close to realized conditions for purposes of making protective action decisions.)
- For the 6 zones to be evaluated for risk reduction by having ANCA start the alert and notification process directly, the alert and notification process will start within 5 minutes of the agent release. (The critical component for protecting the public in those zones closest to the depot is notification time. If ANCA is able to meet its other CSEPP time guidelines, it is prudent for ANCA to start the alarm and notification process to those zones. NICS is aware of several cases where chemical manufacturing facilities that use highly toxic chemicals take responsibility for activating sirens because of immediately adjacent residential areas.)
- Air change distributions will be used as documented in Public Protection Criterion: a Publication Review for Alabama CSEPP for commercial structures and as described in Airtightness of U.S. Dwellings (Sherman, et al. 1998) for residential structures. (The Sherman, et al. study is credible and appropriate for use in modeling for the guidebook.)
- The air filter used in the analysis will be assumed in a bathroom similar in size to the test room in System Effectiveness Test of Home/Commercial Portable Room Air Cleaners (Janney, et al. 2000). (If air filters similar to those tested in the Janney et al. study are to be installed in pink zone residences in the near future, it is appropriate to use the specifications from the study.)

3.6.3. Scenarios to be used for evaluation of shelter in place and evacuation were developed. Assumptions associated with the scenarios were briefed to the Alabama CSEPP jurisdictions at a meeting in November 1999 for that purpose.

Scenarios were developed so that the protective action decision (PAD) process would be simplified (Lemcke 2000). The primary decision for emergency managers is whether to evacuate or shelter in place the people in a particular zone. Scenarios were based on information needed to determine which of these protective actions would be more effective. IEM determined by analyzing QRA and meteorological data that the most important factor in deciding if a zone can shelter effectively is the rate at which dosage accrues inside the shelters.

The time between the arrival of the hazard and the reception of some critical dosage inside a shelter at some fixed point away from the source of the release was determined for 130,000 combinations of QRA accidents with meteorological data. By using the “leakiest shelter” with normal sheltering in place, the times generated by the model are conservative. That is, by using the least protected as the criterion for success, the entire zone, those with the leakiest and less leaky structures and expedient sheltering techniques would be protected. The times generated by the model are the earliest times that the specified dosage would accumulate in a very leaky house using normal sheltering. Critical times for each accident were clustered to construct “scenarios” with similar dosage accumulation characteristics.

NICS agrees that the conclusions regarding dosage accumulation and the conservative assumption for calculating dosage are appropriate for determining scenarios. In addition, the scenario concept is reasonable for constructing a guidebook that can be used during a chemical agent emergency.

3.6.4. Methodology for calculating zone risk and evaluating shelter in place and evacuation options using success criteria will be as presented at the Joint Information Center (JIC) meeting September 24, 1999.

Individual risk, that is, the probability that a particular individual that remains in a particular location could die in a given year due to some specific cause, was estimated by QEM-World™, a computer simulation program developed by IEM for use in CSEPP for evaluating risk. To associate individual risk estimates with a zone, individual risk was computed for a population where all individuals stay in

the same location through time. A sample of 2 million hazards was simulated. Individual risk estimates were computed for both normal and expedient sheltering in place for each zone. They also showed risk estimates for each zone where both sheltering in place and evacuation (called a “balanced response” by IEM) would be used. If under a balanced response, the Public Protection Criterion was still exceeded, further emergency management measures were recommended.

The methods employed by QEM-World™ to estimate risk are part of the proprietary program, and evaluation of those are beyond the scope of this project. The success criterion used to determine if sheltering in place, evacuation or a balanced approach was the Public Protection Criterion (PPC) approved by FEMA and the Department of the Army. As discussed above, the PPC is a conservative and protective criterion that is consistent with CSEPP Policy Paper No. 1.

3.7 Other Issues Affecting Assumptions

3.7.1 Toxicity of Chemical Agents

Dosage accumulation to the No Effects, No Deaths and 1% Lethality levels is dependent on the toxicity levels used for GB, VX and HD. Modeling for the guidebook used the currently approved toxicity levels found in the D2PC reference manual (Lemcke and Myirski 1994).

A review of acute-exposure toxicity estimates for chemical warfare agents conducted by the National Research Council in 1997. The review was conducted for the Department of the Army and was focused on proposed human-toxicity estimates for “healthy male military personnel. They must not be used for civilians.” (NRC, 1997) Based on the rationale of the proposed estimates and the level of good research available to support the estimates, the NRC made recommendations for additional research and evaluated, when possible, whether the proposed standard was too high, appropriate or too low. In general, the NRC found that adjustments were needed to acute-exposure toxicity levels for chemical warfare agents.

The Environmental Protection Agency proposed Acute Exposure Guideline Levels (AEGLs) for the nerve agents, GB (and other G agents) and VX in the May 2, 2001 Federal Register. The comment period for the proposed AEGLs ended June 1, 2001. The National Advisory Committee for AEGLs is reviewing public comments and will make revisions as appropriate. The

results will be established as “interim” AEGLs and will be sent to the National Research Council/National Academy of Sciences (NRC/NAS) for review and comment. Final AEGLs will be published as an NRC/NAS product when there is concurrence on the AEGL values and the scientific rationale used in their development.

AEGLs are developed expressly to represent threshold exposure limits for the general public and are applicable to sensitive subpopulations such as children and the elderly. They have been developed for emergency exposure periods ranging from 10 minutes to 8 hours and follow the general form of the more commonly known Emergency Response Planning Guidelines (ERPGs).

Use of approved toxicity criteria is standard and accepted practice across government and industry. NICS believes that the toxicity criteria used for guidebook development and dosage estimates are appropriate at this time. However, when the AEGLs for GB and VX are finalized, the CSEPP program should adopt them as general public exposure limits and adjust guidebook estimates of dosage accumulation and PARs accordingly.

SECTION 4: FINDINGS AND CONCLUSIONS

- 4.1** Overall, there is a sound technical basis for the assumptions used to develop the Guidebook. Generally, the assumptions were conservative and should yield protective results.
- 4.2** The majority of assumptions are reasonable and appropriate for protecting the public, given the current state of knowledge in the emergency management community about protective actions during chemical emergencies, and given the current state of emergency preparedness in the Alabama CSEPP communities. Exceptions are noted below.
- 4.3** Certain assumptions may not be appropriate because they are at variance with the current state of preparedness in the Alabama CSEPP counties, because they are based on exposure levels that are expected to change, or because they are not supported by current emergency response experience. These assumptions are:
- Warning system infrastructure (sirens and TARs)
 - Sequencing of warning messages
 - Mobilization times following warning messages
 - Overpressurization of special facilities in the IRZ counties
 - Toxicity levels for agents stored at ANCA
- 4.4** For those assumptions in listed in section 4.3, it is not known what effect, if any, a change in the assumptions to reflect current conditions would have on the protective actions recommended by the Guidebook. This would most appropriately be determined by revising the assumptions as indicated in Section 3 and re-running the QEM model. The sensitivity analysis of critical assumptions being undertaken by IEM can determine if revising assumptions will create significant changes in risk to the public and on protective action recommendations that result from using the Guidebook .

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